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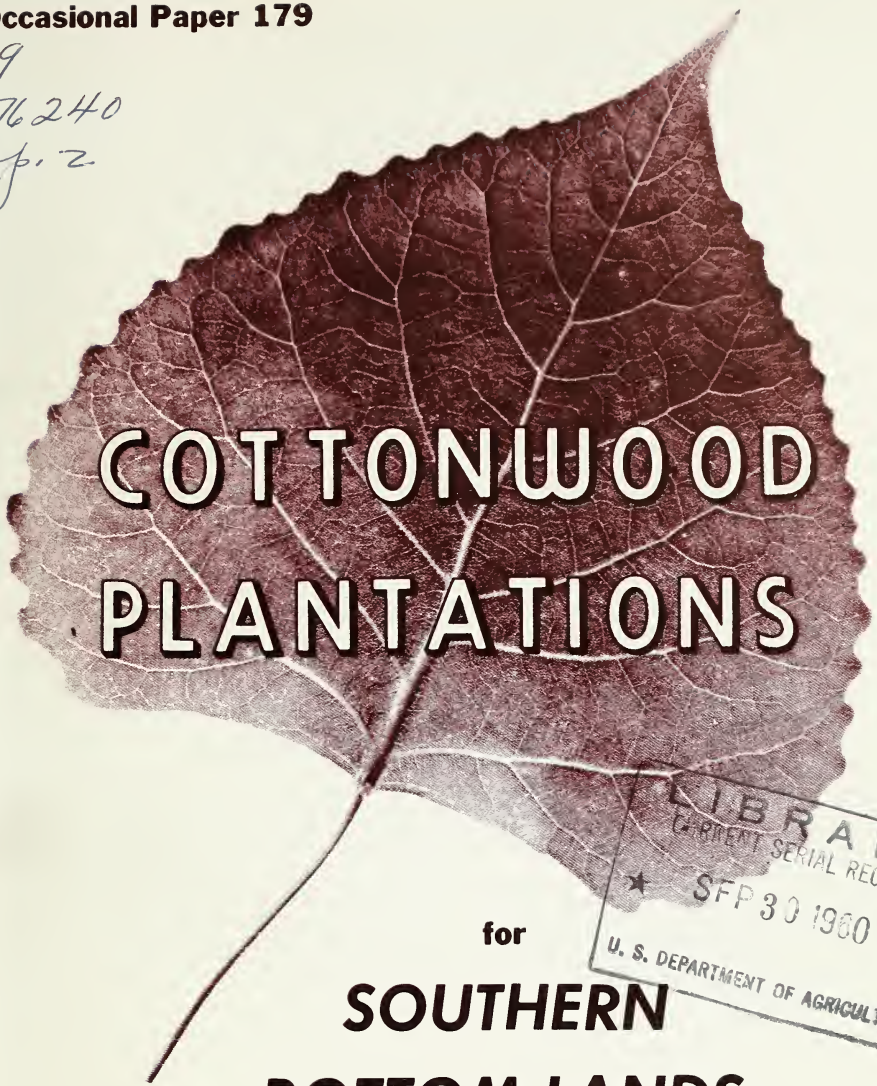

COTTONWOOD PLANTATIONS

for

SOUTHERN BOTTOM LANDS

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Cottonwood planting is rapidly becoming a standard land-management technique for the bottom lands of large southern rivers. One reason for the quickening interest is that cottonwood can be grown on land unsuited for other crops. Even sites densely covered with vines may be planted profitably, and the species' tolerance of flooding and silting enables it to do well on batture and other low sites. Several large timber-using firms have started reforestation programs. Their experience, coupled with research, is steadily enhancing cottonwood planting as a business venture.

COTTONWOOD PLANTATIONS for SOUTHERN BOTTOM LANDS

Louis C. Maisenhelder [1]

Because of its value, rapid growth, and natural preference for bottom-land sites, eastern cottonwood *(Populus deltoides* Bartr.) is an excellent tree to grow in plantations along the Mississippi River and on the flood plains of other large southern rivers.

The present cottonwood plantations in the Yazoo-Mississippi Delta are mostly experimental, but a few companies and individual landholders have planted a considerable acreage for commercial purposes. Interest is increasing as landowners recognize that by planting this fast-growing forest crop they can put certain types of submarginal agricultural land, as well as odd corners and ditch banks, on a paying basis. In addition, a large acreage of heavily cutover and burned-over forest, most of it with a dense growth of weeds, vines, and undesirable tree sprouts, lacks a seed source but can be reclaimed by planting cottonwood. The larger openings on cutover land are also good cottonwood sites if planted before vines and brush come in.

This bulletin summarizes the results of 18 years of research with cottonwood culture at Stoneville, Mississippi[2]. How to grow cottonwood profitably in plantations is now known, though future research and practical application are needed to improve the methods.

RANGE AND USES OF COTTONWOOD

While cottonwood grows naturally as far north as Canada, and as far east and west as Georgia and Kansas, it attains best commercial development on the alluvial bottom lands of the Mississippi River and its tributaries from southern Missouri to the cypress swamps in Louisiana. Here large, pure stands are found on the river islands and the batture lands (the areas between the river and its levees which are unprotected from flooding). Young stands on such lands are commonly mixed with willow, but the faster-growing cottonwood gradually dominates and kills out its associate, so that large cottonwoods

[1] Stationed at the Stoneville Research Center, Stoneville, Mississippi. The Stoneville Research Center is maintained by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

[2] It supersedes Bulletin 485 of the Mississippi Agricultural Experiment Station, **Planting and Growing Cottonwood on Bottomlands,** by Louis C. Maisenhelder, 1951.

are generally found in pure stands. Scattered individuals or small groups also occur in other hardwood forests throughout the bottom lands.

The wood is light in both color and weight, generally straight-grained, and soft but tough. It has good nailing properties and surfaces well except for pieces containing gelatinous tissue, or tension wood, which occurs mostly in crooked or leaning stems. Smoothed surfaces take glue, finishes, and printing well, and the dried wood is notably free from taste and odor. The logs generally yield high proportions of upper-grade lumber and veneer. Cottonwood has long ranked high as a source of both ground and soda pulp, and the improved chemical processes for hardwoods are likely to increase the demand for it.

One or another of these characteristics adapts cottonwood to a large variety of industrial uses. The primary raw-material forms are package and commercial veneer, factory lumber, and pulpwood. For shipping containers it is pre-eminent as both sawed stock and veneer and for all types of use but the heaviest and roughest. It is particularly appreciated for all sorts of food, grocery, and produce containers from beverage bottle crates to berry baskets. As commercial veneer, it is especially well adapted to use as core stock but also appears in common furniture panels, partitions, and drawer bottoms.

The lumber provides the best of wagon-box or truck-body boards, parts for light-colored bedroom and enameled kitchen furniture and trim, sawed core stock, and numerous specialties such as drawing boards. The cordwood is a favorite for the highest class of book and magazine paper and for all types of wallboard. It shows unusual promise for newsprint.

Cottonwood is one of the least durable of woods, is inclined to shrink excessively in drying, and warps considerably if not cured carefully. In common with most hardwoods, therefore, it has not generally been regarded as an appropriate source of construction lumber. Nevertheless, if kept clear of the ground and free of permanent or frequent moistening, it tolerates normal weathering exceptionally well. If skillfully cured before installation, it stays put and takes paint readily. It has been used successfully as subflooring, sheathing, and siding.

Annual production of cottonwood lumber in the South in recent years has averaged about 90 million board feet. Most of this comes from the Delta regions of Mississippi, Arkansas, and Louisiana. Cottonwood ranks fifth nationally among hardwood veneer species in the amount consumed.

GROWTH RATE

Cottonwood usually matures in about 45 years, but some stands continue rapid growth for a longer period. In natural stands on the better sites, it often grows 2/3 to 1 inch in diameter and 4 to 5 feet in height annually up to about 25 years of age. Planted trees do better than this. At Stoneville, trees planted as cuttings have increased 10 feet in height during their third growing season. The best first-year growth from cuttings has been 19.0 feet in height for a single tree and 13.5 feet for a stand. Trees up to 25 or 30 years of age grow only a little slower. Well-stocked natural stands in the Mississippi Valley contain trees that average 20 inches d.b.h. (diameter at breast height, 4½ feet above ground) and 120 feet tall at 35 years of age. Growth usually begins to decline sharply at about this age, so that at least part of the trees should be harvested.

In the fall of 1947 a commercial logging removed about 60 percent of the volume from a 55-year-old stand whose diameter growth had declined noticeably 10 years before. Cutting was on a tree-selection basis, and took mostly trees of poor to medium vigor. The release given the remaining cottonwoods of good vigor stimulated their diameter growth, even though many were 30 inches d.b.h. or over (fig. 1).

Figure 1.—*A 55-year-old unmanaged cottonwood stand on batture land. A commercial timber sale has just removed about one-third of the total sawtimber volume of 36,000 board feet per acre (Doyle rule). The remaining trees, which will be cut some 10 years hence, range from 20 to 32 inches in diameter and are still increasing rapidly in volume and value. Managed plantations on comparable sites can be expected to do as well or better.*

The trees, which were on a good batture site, had grown 3.2 inches in diameter in the decade preceding the cut. Two years afterwards they were growing at the rate of 4.8 inches in 10 years—an increase of 50 percent.

Growth rate varies with site, the moister locations ordinarily producing the better growth. In one plantation, 6-year-old trees on a ridge averaged 2.6 inches d.b.h. and 22 feet in height. In the same plantation but on a gentle slope from ridge to swamp—a moister location than the ridge—trees averaged 4.1 inches d.b.h. and 31 feet high. Similar variations can be expected in most areas.

In well-stocked natural stands, cottonwood prunes itself very well and produces a long, straight trunk that is generally clear of limbs for at least 50 feet when mature. In plantations, where original spacing is usually wider than in young natural stands, artificial pruning may be necessary to obtain comparable stem form.[3] Natural stands on good sites have yielded about 24 cords of pulpwood at 10 years and 50 cords at 15 years. The volume in board feet per acre, Doyle rule, has been estimated at 5,700 at 20 years, 10,700 at 25 years, 19,200 at 30 years, and 27,500 at 35 years. Most natural stands, especially over large areas, are not fully stocked and therefore do not attain these yields, but in Iowa plantations 30 to 40 years old with high survival and uniform spacing seem to be producing at comparable rates.

[3] Johnson, R. L. **Pruning Cottonwood.** South. Lumberman 198(2473): 28-29, illus. 1959.

NATURAL REPRODUCTION

Cottonwood reproduces naturally from seed only under exacting conditions. Bare soil that remains saturated but not flooded for long periods during seedfall is essential. Natural reproduction occurs principally on sand bars and other accretion lands along the larger rivers. Here, growing conditions are optimum, and extensive pure stands or mixtures with willow result. Less extensive stands occur on protected sites along water courses, drainage ditches, and borrow pits. Old fields occasionally seed to cottonwood during years of frequent rainfall.

The site must remain moist and free from vegetation that would overtop the seedlings during the first growing season. Cottonwood will stand silting if only a short length of the stem is covered. It is, however, extremely intolerant of shade and will not develop even under very sparse stands of trees. Adequate natural reproduction is almost never seen on land from which mature cottonwood has been harvested, for seedlings that start are soon killed by the shade from residual trees and from the heavy ground cover that develops after cutting. Where cottonwood is found in mixed hardwood stands, it has originated in openings.

PLANTING AND CULTIVATING

Hardwood trees require more care than pine if successful plantations are to be established, and they will not do well if untended. This fact is usually not appreciated by the novice tree planter, and failure to provide the proper care is one of the major reasons for the small number of acceptable plantings.

For farmers, the care of the cottonwood plantation during the first year will at times coincide with the peak of work on field crops, but it must be given the proper priority in the farm program. The trees will not tolerate being neglected in favor of cotton and beans.

CHOICE OF PLANTING SITE

In the Mississippi Delta cottonwood does best on moist, well-drained fine sandy loam or silts in the batture (fig. 2),

Figure 2.—
A 5-year-old cottonwood plantation on a good sandy loam site. Dominant trees average about 40 feet tall and 5 inches in diameter. The largest tree is 45 feet tall and 8.4 inches in diameter. The trees have been pruned.

but it also thrives on the heavier clays of gentle slopes bordering swamps or sloughs. The heavy clay "buckshot" soils which dry out and crack in the late summer are less favorable, but planting can succeed if the best practices are carefully followed and if the first summer is not unusually dry. Growth on such soils is relatively slow (fig. 3).

Heavy clay that has lost all its organic matter by exhaustive cropping and has become stiff and waxy at the surface will not grow cottonwood. Tests have shown that cottonwood is unable to obtain water from these soils when they still contain 30 percent moisture and feel damp to the touch. A stunted, sparse growth of weeds on a field which has been abandoned for several seasons is usually an indication of these conditions. Ten years of weed growth were needed on one such old field to restore enough organic matter to the soil so that green ash and soft and cedar elms were able to seed in naturally. Such areas might be made suitable for cottonwood by plowing under leguminous cover crops for several years, thus building up the organic content of the soil; but this practice has not been tested. Irrigation during dry periods is also being tried. Most other bottom-land sites in the Mississippi Delta seem satisfactory for cottonwood unless they are extremely dry in the late summer and fall, or are under water during the growing season.

One land condition which may or may not require planting is the "brush patch," in which annual weeds, briars, vines, and shrubs form a dense ground cover. Where this is the only vegetation, planting is needed. Often, however, close examination discloses tree sprouts and seedlings, usually of other species than cottonwood. If not too heavy, the briars and weeds act as a nurse crop for the trees and are usually more beneficial than harmful. If as many as 700 to 1,000 good seedlings per acre (one to each 40 or 60 square feet) of desirable species are found, planting is unnecessary and a suitable stand will usually develop without aid.

Ridges of coarse sand (former sandbars), common in the batture, are unsuitable for cottonwood. These can usually be recognized by their complete lack of any tree growth; in fact, when the water table falls in summer they commonly become so dry that they support only a sparse stand of grass. A few borings with a soil

Figure 3.—
These cottonwoods were planted on a dry ridge of heavy clay soil. After 15 years they average only 45 feet tall and 5 inches in diameter.

auger will identify this condition. Swampy areas where floods or backwaters are likely to submerge the small trees completely for several days during the growing season also are entirely unsuitable. Cottonwood does not grow well on poorly drained sites.

In general, cottonwood does not survive or grow as well in the small bottoms of upland hardwood or pine areas as it does on the flood plain of large rivers. Often the non-Delta soils are shallow, dry, or impervious and change from very wet to very dry in a short time. As it is often difficult to evaluate a site from its appearance,[4] the best course is to try small-scale planting a year before undertaking a big job on a new area.

For erosion-control work, cottonwoods can serve as living dams (fig. 4) in moist gully bottoms of the eroding bluffs along the eastern edge of the Delta. For this purpose, trees are often planted 6 inches apart in the row, with 18 to 24 inches between rows. The rows are set at right angles to the water course, so as to slow the washing of soil. The fact that it is one of the few trees that endures silting-in around the stem adds to cottonwood's utility for this purpose.

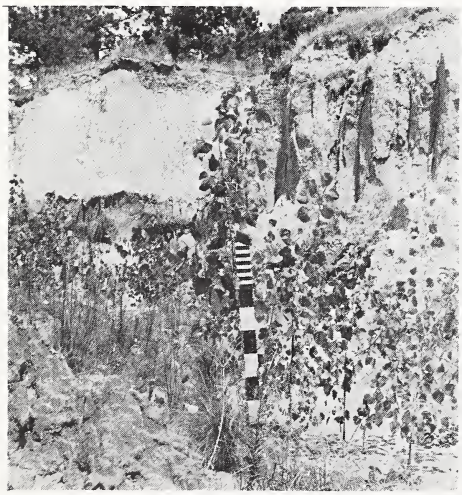


Figure 4.—*Cottonwood used as a living dam to control erosion in the brown loam bluffs of Mississippi.*

SITE PREPARATION

Before being planted, all sites should be cleared of existing vegetation. Planting cottonwood without site preparation and subsequent cultivation is almost always futile. Weeds and vines kill many of the trees and greatly reduce the vigor and growth of survivors. Even if survival is occasionally good, vigor is likely to be poor.

Where the ground cover is annual weeds and vines, clearing can be done by disking alone. Cross-cultivation with a disk harrow or a heavy bush and bog disk is effective. Very thick sods are among the most difficult sites to prepare for planting, and sometimes require 4 diskings. If vines, shrubs, and undesirable trees are abundant, as in areas covered with buttonbush or in pure boxelder stands, bulldozing prior to disking is recommended. Bulldozing should remove as little of the topsoil as possible.

Whatever method is used, the ground should be left level to facilitate later machine cultivation. To avoid forming large clods, which are easily rolled onto the small trees during cultivation, it is best to work the planting site in the fall, before it has been soaked by winter rains.

Usually the most practical procedure is to clear the entire planting area, but where this is too costly, planting can be done on cleared strips about 10 feet in width, and with the debris windrowed between them. Spacing between rows necessarily exceeds the customary 10 feet. Difficulty of cultivation (chiefly hand work) may offset some of the savings from partial clearing.

New developments in strip cultivation are likely. The Chicago Mill and Lumber Company has established a plantation near Greenville, Mississippi, on narrow strips cleared at one pass with a bulldozer that scraped off a heavy cover of vines and annual weeds. Rooted trees 6 to 8 feet tall were planted, and no cultivating was done (fig. 5).

Underplanting cottonwood cuttings in stands of low-grade trees has failed even

[4] Broadfoot, W. M. **Field Guide for Evaluating Cottonwood Sites.** U. S. Forest Service, Southern Forest Experiment Station Occasional Paper 178, 6 pages, illus. 1960

Figure 5.—*One-year-old rooted trees just after they were planted on a 9-foot strip cleared with a bulldozer. Spacing is 20 by 20 feet.*

when the overstory trees were frilled and treated with chemicals at the time of planting. Cultivation was impossible, and falling limbs of deadened trees deformed most of the cottonwoods that survived the competition with grass and brush.

Planting in furrows made with a middle-buster plow stimulates growth on the drier sites, but increases the difficulty of machine cultivation. A better practice, suitable on any site with a sandy loam soil free from tree roots, is to use a tractor-drawn subsoil plow to break through the compact layers of soil and open a narrow slit in which to plant the trees. Subsoiling simplifies the planting job and facilitates penetration of moisture to the roots. All the benefits of furrowing are obtained and, because the ground is left flat, cultivation by any method is possible. Subsoiling or furrowing operations are in addition to disking. Cross-disking an acre of land with a wheel tractor and a two-row disk harrow requires 1.1 hours. Subsoiling one acre with a wheel tractor takes 0.6 hour.

To clear sites on which the trees can be easily uprooted by a bulldozer requires 2 to 3 hours per acre.

Special site preparation usually is not needed on areas logged in late summer or during the fall and winter just prior to planting, for logging scarifies the ground. Earlier logging will be followed by a crop of weeds which must be removed; a bush and bog disk will do the job. If the openings created by logging are less than ¼-acre in size, it is probably best not to attempt planting.

Less satisfactory practices.—Several additional site preparation practices have been tested. They are not recommended for general use but may be adaptable to special situations.

Two fire-line plows failed to clear strips wide enough to permit machine cultivation. The Ranger's Pal plow was too light to make a satisfactory furrow in heavy stands of pepper-vine and trumpet-creeper. A heavier hydraulically controlled plow that made a furrow about 3 feet wide seemed satisfactory at the time of plowing, but by the end of the first

growing season vine sprouts from along the edges of the furrow had closed in over most of the planted cottonwood and were seriously restricting growth.

A self-propelled rotary tiller has done a good job of preparing planting strips in heavy vine stands but would not be suitable where trees are 3 inches or more in diameter. Such equipment is not as generally available to landowners as are disks and bulldozers, and is expensive.

SPACING

How far apart should cottonwoods be planted? Spacings ranging from 6 by 10 to 10 by 10 feet (providing from 60 to 100 square feet of growing space per tree) are most satisfactory for the production of both pulpwood and sawlogs. At such spacing the trees will possibly require pruning, but should have room enough to reach pulpwood size before the first thinning becomes necessary. These spacings are also convenient for machine cultivation.

At spacings of 6 by 6 and 4 by 10 feet, survival as well as height and diameter growth are less than in wider spacings. Spacing wider than 10 by 10 feet may cause understocked stands unless adequate care is taken to insure high survival; furthermore, the quality of the trees may be inferior because early natural pruning may not occur. The cultivation method to be used will also influence the choice of spacing. In general, present recommendations for spacing are:

On sites where at least three-fourths of the cuttings can be expected to survive and grow vigorously, space 10 by 10 feet.

On drier and less productive land, where not more than two-thirds of the cuttings can be expected to grow vigorously, make rows 10 feet apart and set trees 6 to 8 feet apart in the row.

TIME OF PLANTING

While planting may be done at any time between the first severe frost in fall and the opening of buds in spring, February is the best month in the Yazoo-Mississippi Delta. The ground is usually wetter than in the two preceding months, especially on the higher sites; and drying winds, high water, rabbits, and other injurious agencies will have less time to damage the stock before it sends out roots and attains some recuperative capacity. On a big planting job, work may start in December and continue into April. Delayed planting may be desirable on very low sites where backwater or spring floods interfere during the normal planting season. Late planting, however, requires keeping stock dormant by cold storage.

Floods which entirely submerge the trees while they are dormant do not seriously affect survival. One Delta site, planted the first week in March, was immediately flooded to a depth of 8 feet; the cuttings remained under water until the first week in April, yet 75 percent of them leafed out. Once the trees leaf out, however, 48 hours of complete submergence will kill nearly all of them. Ten or fifteen percent may sprout a second time, but their vigor will be poor and growth will be slow. Partial submergence with some or all of the leaves remaining above water, even for 2 to 4 months, is not harmful to cuttings or older trees unless the water loses its oxygen or becomes hot enough to injure the cambium tissue of the stem.

Delayed planting is advantageous only on the lower, wetter sites—not on the drier ridges. The disadvantage of late planting is that it shortens the growing season so much that cuttings may not grow tall enough to stay above water in the second spring.

Rainfall often controls plantation success. On drier sites bordering sloughs, stored stock may be planted as late as the first week in May with fair success, provided that there is sufficient rainfall throughout the rest of the growing season. As summer droughts are common, however, it is safer to regard April 30 as the latest planting date on dry sites.

Planting in swamps immediately after floodwaters recede has not been tried, but appears likely to succeed. With dormant stock, dates as late as early June may be feasible for swamp planting, as

natural reproduction often starts that late and survives unless submerged by second-year floods. Probably planting should not be attempted where spring floods deep enough to submerge the seedlings completely are expected annually.

PLANTING STOCK

While cottonwood can be successfully planted as rooted seedlings, the use of unrooted cuttings is recommended. Cuttings survive and grow as well as seedlings, and are cheaper and easier to procure and plant. One-year-old rooted plants 6 to 8 feet tall, either seedlings or trees grown in a nursery from cuttings, may be preferable on sites where competition from unwanted vegetation is severe and cultivation is impractical.

There are two practical classes of unrooted planting stock: (1) Cuttings taken from 1- to 3-year-old seedlings; such cuttings may be entirely stem material or may include a part of the seedling root. (2) Stem cuttings from 1- or 2-year-old sprouts originating within 6 inches of the rootcollar on stumps from 1 to 5 years old. Low material from older stumps has not yet been tested but would probably be satisfactory.

Cuttings from 1-year-old wood in the crowns of trees 4 years and older are not recommended for field planting; they frequently fail to take root. Tests with such cuttings from the crowns of trees 10 to 25 years of age showed very poor first-year survival—6 to 16 percent. Shoots from such cuttings as do root, however, will show increased survival if planted, but this increased viability will become apparent only after 3 or 4 years. "Fourth-generation" shoots from cuttings of older crowns have given survivals of 85 percent. This procedure for improving survival will be most useful to the tree breeder or nurseryman interested in producing planting stock from trees of superior growth and stem form. A number of such "plus" cottonwood trees and European hybrid poplars having eastern cottonwood as one parent are being tested at the Stoneville Research Center and elsewhere in eastern United States as a source of elite planting stock.

While supplies of elite trees are being developed, the cottonwood grower can immediately improve the stock he plants by taking his cuttings from trees of better than average height and diameter growth. The stricter the selection, the better will be the results. The investment required to establish and care for a cottonwood plantation is high, and only the best planting stock should be used.

Where only a few thousand cuttings are desired, they can usually be obtained cheaply along drainage ditches or in highway borrow pits on the safe side of the levee. Larger quantities rarely occur except on bars along the Mississippi and other large rivers, and such sites may be difficult of access during January and February, when the collecting must be done. The establishment of cutting nurseries, therefore, appears desirable where a large planting program is planned. Instructions for setting up such nurseries are given later in this publication.

Planting stock can be harvested either by pulling seedlings up by the roots or by cutting them off about an inch above the ground. Cutting is the fastest and cheapest and has the further advantage that the rootstock left in the ground will send up sprouts which can be harvested year after year. Thus, well-located natural stands can serve as nurseries.

For successful planting, seedlings and cuttings must be dormant. The succulent green tissue of rapid growth may persist for a short time after the first fall frost, but the buds and current season's wood must have stopped growing and be hardened before cuttings are made.

After being harvested, the cottonwood switches must be cut to the proper length for planting—twenty-inch lengths are suitable for most areas. Twenty-five-inch lengths help prevent complete submergence on sites subject to shallow flooding during the growing season and are also recommended for deep planting on dry sites.

All lateral branches should be trimmed off flush with the main stem; large laterals may be made into cuttings. Cuttings should range from ⅜ to ¾ inch in

diameter at the small end. Sizes smaller than this dry out excessively after planting and contain too little stored food to give the tree a good start. Cuttings larger than ¾ inch are hard to handle and plant, though once in the ground their survival and growth are good. Crooked sections of stem should be discarded, since they cannot be pushed into the ground easily and will usually be planted improperly. On cuttings that include some root, the taproot should be cut back to 15 inches or less, until it is stiff enough to insert in the planting hole, and the larger side roots should be pruned sufficiently to permit this insertion.

Cuttings can be mass-produced by laying several switches at a time on a block and chopping them all off at once at right angles to the axis of the stem. Chopping must not smash or split the ends, since this can cause failure to sprout. For ease in handling and counting, cuttings should be tied in bundles of 100 with all the butt ends pointing in the same direction.

Costs of making cuttings.—In a nursery, cutting sufficient full-length sprouts with a machete to yield a thousand 20-inch cuttings and bunching them for transportation takes about ¾ man-hour. Trimming the laterals and cutting shoots to length has taken 4 man-hours of additional work. Counting and bundling has taken 1¼ hours more. In one trial a small circular power saw produced cuttings as rapidly as a machete and without splitting the ends. Practical experience will reduce production time and costs.

Storing cuttings.—For a few days of storage during the planting season, the butt ends of cuttings and the roots of seedlings may be placed in water (ditches or stump holes) or heeled into moist soil. Cuttings require less care than rooted seedlings, but should not be exposed to the sun or wind. Covering them with wet burlap sacks is good practice.

When planting will be done after the start of the normal growing season, the buds must be prevented from opening. A cold storage locker where the temperature can be maintained between 28° F. and 32° F. will be necessary. Cold air must be kept circulating around the cuttings to prevent them from sprouting in the locker. Bundles should be set butt end down in a 2- to 3-inch layer of moist sand on wooden duckboards placed over the permanent floor. To save space, several layers of bundles can be piled one on top of the other. Each layer should be covered with wet burlap sacking over which is spread a layer of wet sand to serve as a moist base for the next higher tier of bundles. When it is necessary to have more than 36 bundles per layer, a perforated flue or chimney, about 6 inches square, should run through the center of the whole pile to ensure air circulation. Sand, burlap, and cuttings should be thoroughly sprinkled with water twice a week.

Survival of cuttings stored in this manner for 8 months has been as high as 75 percent. Results are best when cuttings are planted the same day they are removed from storage.

METHOD OF PLANTING

The spacing will have been chosen well before planting time, but the location of the rows should be clearly marked just prior to planting. In nurseries (fig. 6) or

Figure 6.—*Preparing planting rows in the nursery with a three-unit subsoil plow. Rows are 36 inches apart.*

on disked areas where the ground is free of roots this is best done with a subsoil plow set for a depth of 15 inches. The plow should have a small point, for if the slit it makes is too wide the soil may not settle properly about the cuttings.

When cross-cultivation is planned, it is best to mark the rows in both directions, but otherwise the spacing in the row can be determined by pacing the distance as the planting is done. The cross-marking can be accomplished with ordinary farm row-marking equipment. If planting strips are used, the trees are merely set in the middle of the strip. On rough woods areas, uneven spacing between rows and between trees within the row will often be necessary to avoid holes, stumps, down trees, and other debris.

Where subsoiling is impractical, cuttings can be set in holes punched with an iron rod like that illustrated in Figure 7. Such a rod is easy and cheap to make, and quick to use. It should have a step 15 inches from one end for pushing it into hard ground. The upper end should form

Figure 7.—*Four steps in planting a cottonwood cutting: A—Starting the planting rod into the ground. B—Pushing rod down to the step (15 inches). C—Putting a 20-inch cutting in the hole. D—Closing the hole by a kick of the heel.*

a handle, preferably L-shaped, and the lower end should be pointed. A 5/8-inch rod is preferable for most seedlings and sprout cuttings, but a 3/8-inch rod is best for the smaller cuttings made from the tops of seedlings.

There must be contact between the planted tree and the soil. Cuttings must be pushed all the way down to the bottom of the hole. Shallow planting results in poor survival and slow height growth. The top of the hole should be closed by a kick of the heel. If the soil is very wet and soft, the cuttings may sometimes be pushed in 15 inches, so that no rod is needed. In the drier soils, it is undesirable to plant without a rod or to use a rod of smaller diameter than the cuttings, for the bark may be stripped off or the cutting broken as it is forced into the ground.

Mattocks or wedge-shaped pine planting bars are slower than a rod, especially in wet clay soils, and do not improve survival or growth.

The cost of planting varies with the efficiency of the crew and the size of the job. Fairly well-trained men on a small job took 5½ man-hours to plant an acre of 20-inch cuttings at 6- by 10-foot spacing (726 trees). With a less experienced crew and more brush, 6 man-hours were required to plant an acre at 10- by 10-foot spacing (436 trees).

CULTIVATION

From the very earliest attempts to grow cottonwood, it has been apparent that this tree is most intolerant of competition from weeds and vines. Heavy mats of trumpet-creeper and pepper-vine, often called buckvine, are probably the worst ground cover, but heavy grass sods also reduce survival greatly and are very difficult to control.

During the plantation's first year, cultivation is absolutely essential. It not only controls weeds but also conserves soil moisture and incorporates organic matter. Growth of the trees is directly related to the thoroughness of the cultivation. Failure to cultivate whenever it is required always results in reduced height and vigor and almost as frequently causes total failure of the plantation. For farmers this means that there will be another demand on machinery and labor at the busiest season, but without prompt, thorough cultivation the planting of cottonwood is money wasted.

Number of cultivations.—Cultivations must be frequent enough so that the average height of weeds at no time exceeds one-half the height of the trees. A minimum of two cultivations and a maximum of five are usually necessary during the first growing season. They should be timed so as to eliminate both the spring weeds and late summer weeds such as ragweed, coffee weed *(Sesbania exaltata),* and goldenrod.

Usually the first cultivation is made in early or mid-April and followed up once or twice a month through July. These are approximate dates only; the best rule to guide time and number of cultivations is the basic one of never allowing weeds to become more than half as tall as the trees.

Cultivation is rarely necessary in the second growing season, although weeds should never be allowed to overtop the trees.

Recommended cultivation methods.—The following cultivation methods are recommended: (1) Cross-disking between the rows, (2) disking between the rows in one direction only, (3) straddling the row with a cultivator that works both sides at the same time, and (4) hand hoeing as a supplement to machine work.

Cross-disking is the cheapest and best type of machine cultivation. The 10- by 10-foot spacing recommended earlier can be varied slightly according to the width of the disk. The machine should work the entire area between rows on one trip, and should also come as close to the trees as possible without damaging them. If trees are regularly spaced, a minimum of hand work is necessary, but where reasonably cheap labor is available it is often advantageous to hoe any large weeds missed by the second cultivation.

Disking in a single direction is less desirable than cross-disking because it leaves a continuous strip of weeds in the row. One hand hoeing is usually needed, be-

cause the trees do not emerge from this band of weeds as easily as from the narrow ring left by cross-disking.

From results obtained in the nursery it would appear that cultivating with a machine that straddles the row of trees, though somewhat more costly than other methods, is a most advantageous way to control weeds and stimulate general vigor and height growth. One-way straddle cultivation is especially suited to narrow planting strips; cross-cultivation is possible at any spacing that permits passage of a tractor. When the trees become too tall to pass without damage beneath the machine, hand-hoeing, disking, or mowing must be resorted to. The method is not adaptable where roots and stumps are numerous.

Hand hoeing with ordinary cotton-chopping hoes to clear an area 5 feet in diameter around each tree is the most expensive method, although a successful one. It is very useful as a supplement to machine work or in treating small areas when labor is cheap and plentiful. It is the only alternative on rough woods sites where machinery cannot be used.

Crops like corn or beans can often be planted between the tree rows for several years, until the shade becomes too dense. The tree rows should be about 9 feet apart, with cuttings 6 to 8 feet apart in the row, to make a 6- by 9-foot or 8- by 9-foot spacing. The trees will be cultivated as the crop is worked, and will thus provide an immediate cash return with little extra outlay of money or labor. In a plantation on a well-prepared abandoned field, weeds between rows were controlled by a broadcast sowing of soybeans. Tree spacing was 6 by 11 feet, to permit harvesting the beans with a combine. In the first year, two straddle cultivations kept down weeds in narrow strips on each side of the tree rows (fig. 8). In the second year no beans were sown, and after a single disking the trees were safely ahead of all competition.

Several other methods of weed control have been tested and found unsatisfactory.

Flame cultivation with a machine used in cotton culture killed 20 percent of the cuttings by destroying the cambium layer. Even if less lethal flame techniques should be worked out, special machines of more rugged construction than the cotton cultivators would be needed on rough sites.

Sterilizing the soil by scattering white arsenic on top of the ground controlled annual weeds fairly well during the first year, but the deeper rooted vines and brush survived and soon overtopped the cuttings. The possibility of poisoning humans, livestock, and wildlife is a further drawback to this method.

When strips were prepared with the Mathis fireline plow but not cultivated after planting, the vines were controlled but annual weeds soon overtopped the seedlings.

Figure 8.—*Six-week-old soybeans growing between first-year trees spaced 6 by 11 feet.*

Costs.—The costs of cultivation will vary with the locality and the method, size, and type of operation, but the requirements in Table 1 are typical under many conditions.

Table 1.—*Typical requirements per acre for cultivating cottonwood plantations*[1]

Method	Man- or machine-hours
Hand hoeing alone	32.00
Hand hoeing to supplement machine work in plantations disked one way	25.00
Cross-disking between rows	.72
Disking between rows, one way only	.36
Cultivating astraddle the planting strip	1.00

[1] Six- by ten-foot spacing for all methods except cross-disking, where spacing is taken as 10 by 10 feet.

Use of 5-foot square patches of building paper as a mulch to keep down weeds was prohibitively expensive, and the vegetation around the patches and some which came up through breaks in the paper seriously retarded tree growth.

Pre-planting control of weeds with chemicals has not been found feasible so far.

FERTILIZATION

Fertilizing cottonwood cuttings with ammonium nitrate gives varying results, depending upon the amount of rain during the growing season. In wet years almost any combination of fertilization and cultivation is satisfactory, but during dry seasons the weeds are stimulated more than the trees, thus increasing the need for cultivation. When used at planting time, the nitrate should be applied at the rate of 2 ounces per tree. To prevent damaging the roots, it should be distributed in a ring on the surface of the ground around each cutting, but at least 6 inches away from the cutting itself.

With good moisture conditions, hoeing combined with fertilization has produced survivals of 75 to 95 percent and individual trees 10 to 12 feet high in a single season. Under adverse conditions mortality has been very heavy.

Since fertilizing costs about $4 per acre (726 trees) and depends for success on the amount and time of rain, it cannot be recommended except perhaps as a gamble with late plantings in swamps to help offset the effects of a shortened growing season. On such wet sites the ill effects of fertilizing should be at a minimum.

Fertilizer will probably be more beneficial in stands 2 years of age or older, and studies now being made should permit recommendations of specific practices.

SURVIVAL

Survival at the end of the first season in the field usually varies from 65 to 90 percent, depending on the age of cutting stock, site, thoroughness of cultivation, and weather. The moister sites generally show the better survival and growth.

At the end of the first year a satisfactory plantation should contain at least 400 well-spaced trees tall enough to stay above ordinary floodwater and vigorous enough to outgrow competition without further cultivation. With 6- by 10-foot spacing, about 56 percent survival is required to obtain 400 trees. For most Delta sites, the minimum satisfactory first-year height is 36 inches. Experience may suggest shorter or taller minimums for particular localities. If the total survival is over 80 percent, only 40 to 50 percent of the trees need be over 36 inches tall, since enough of the shorter trees to make up the difference can usually outgrow the competition in the second year. Where competing vegetation is considerably less than 36 inches tall, trees averaging shorter than 36 inches at the end of the first year may survive satisfactorily.

Replanting small blank spaces before the start of the second growing season cannot be advised, since replants will be suppressed by initial survivors in a year or so. When whole spots of more than ⅛-acre have failed, they can be replanted if the cause of the failure is unlikely to recur.

On good sites few trees die after the first year. Second-year mortality in the Delta averages 5 or 6 percent. Outside the Delta, it has ranged from 8 to 54 percent.

GROWING NURSERY STOCK

A nursery for growing cottonwood planting stock will pay for itself whenever a few thousand cuttings are needed annually for several years. It should be established on moist sandy loam in an accessible location. Exceptionally fertile soil should be avoided as root systems are likely to grow so large in 2 years that most of the shoots will be above maximum size for cuttings. Less fertile soils yield more crops before the shoots become so large that the nursery must be replanted.

CUTTING NURSERIES

The nursery may be started from seed, but it is much easier and more economical to use cuttings of the same specifications as for field planting.

Especially for a nursery, cuttings should be taken from none but the most vigorous 1- to 3-year-old seedlings, since the trees to be grown will have the characteristics of the parent. The most vigorous seedlings are usually the tallest, and their stems are dark green rather than dull brown.

To obtain the highest grade of growing stock, only the best 20 percent or less of the switches in natural stands should be selected for use as cuttings. Work is now under way to demonstrate the superiority of selected stock and, in time, certified better-than-average cuttings should be available from state and commercial nurseries.

Cuttings should be set in the nursery at a spacing of 1 foot by 3 feet, or about 14,500 per acre (fig. 9). The 3 feet between rows allows for economical tillage with either a 4-row cotton cultivator or smaller 1-row equipment.

Five or six cultivations with standard straddle-row cotton cultivators are advisable during the first year. These should begin about April 1 and be repeated every 10 days until June 1. After this, the trees will be too tall for straddle cultivation, and their shade will retard weeds. A small amount of hand hoeing is frequently desirable to control late-summer weeds. Two or three cultivations are usually adequate the second season; after that the sprouts will outgrow everything except possibly Johnson grass, but sod should never be permitted to form. The nursery must also be protected from fire and grazing throughout its lifetime.

With average site and weather, annual per-acre production will be approximately 25,000 twenty-inch cuttings—enough to plant 57 acres at 10- by 10-foot spacing. From three to six annual harvests, the number depending on the fertility of the soil, can be made from the same rootstocks before the sprouts become too large in diameter for economical use. After the first year, branches from some of the main stems of sprouts will yield ⅜-inch cuttings.

The cost of establishing a 1-acre nursery and maintaining it for 6 years (at 1960 wage scales) would be about $135—chiefly for labor. Thus the nursery charges (exclusive of harvesting, trimming, bundling, storage, and transportation) against the approximately 150,000 cuttings yielded are 90 cents per thousand.

Figure 9.—*One-year-old cottonwood sprouts on two-year-old rootstocks in a nursery started from cuttings. Spacing is 1 foot by 3 feet.*

NURSERY STOCK FROM SEED

Raising cottonwood nursery stock from seed is an exacting operation not recommended for general use. It will, however, be necessary to employ this method in any tree-breeding work directed toward the development of elite strains. The requirements for propagation in the nursery also indicate the conditions which must exist if successful natural regeneration is sought.

Seed collection.—In the central portion of the Yazoo-Mississippi Delta cottonwood seed generally matures and falls from about the first of May until late July, with dissemination at its peak in late May. Abundant crops are produced every year. Seed may be safely collected after the first of May, and frequently collection is possible from a few late-maturing trees in June. A good rule is to collect after the pods have started to turn brown and the first pods have begun to open.

The best seed-bearers are large, open-grown trees. Usually little seed can be had from trees less than 10 inches in diameter at breast height or less than 10 years old. Seed is borne only by female trees. Male trees usually have red flowers, and female trees yellow flowers.

The green pods or capsules are most easily gathered from tops of trees felled by loggers. A large tree may yield over a bushel of pods, from which several pounds of seed can be extracted. A pound of seed, clean enough for sowing, contains about one-half million seeds.

If stored in bulk following collection, the unopened green pods will heat; they should therefore be spread out in thin layers to cure or dry at ordinary room temperatures. After 2 or 3 days most of the pods will still be closed but sufficiently dry to be easily opened. They may be air-dried for a week with little or no loss of seed viability, and 3 weeks of moist cold storage (at about 40° F.) is possible.

Crushing or rubbing the pods against a coarse screen releases the seed, and to some extent loosens it from the cottony matrix. Parts of the pods will fall through the screen with the seed and its cotton. This mixture is known as "unclean seed." If large quantities are to be handled, grain hammermills or other machines can be used.

The seed is separated from the cotton by rubbing over a screen wire of small mesh, such as a window screen. This produces "clean" seed ready for sowing. Only about 20 percent of the seeds actually handled are readily extractable; beyond this point, further rubbing yields so few seeds that it is probably unprofitable.

The seed should be sown immediately after extraction. Its viability is greatly reduced in a few days by dry open storage, although it may be safely kept for a week or more in moist cold storage.

Seed sowing.—As for cuttings, the best nursery soil is a fertile, fine sandy loam. A suitable arrangement is to have seedbeds 4 feet wide, with 1-foot alleys or paths between. The beds are formed by breaking out the alley with a middle-buster plow, then leveling off the bed with a rake or a drag.

The seed is sown on the surface by hand, either broadcast or in drills 6 inches or more apart. It should not be covered. Broadcast beds are more easily sown and will produce more plantable trees per unit area owing to the better distribution of seed, but drilled beds are more easily weeded and may be hoed. Cottonwood seed is so small that care is needed to distribute it uniformly on the bed. Mixing the seed with a dry sandy soil will help, or sometimes unclean seed is sown so that the location of the cotton on the bed indicates the distribution.

Fresh seed is highly viable, with 80 to 90 percent germination. Actual numbers of trees per 100 seeds sown will be much lower, for the young seedlings are so fragile that the slightest adversity in field conditions causes considerable loss. It is therefore wise to sow heavily to ensure a fully stocked stand, and thin later to the desired density. A good stand can generally be produced from 1 ounce of clean seed per 100 square feet of seedbed, or about 300 seeds per square foot. If drill-sown, 100 seeds per linear foot are adequate.

Constant, ample moisture for at least 3 days is required for germination and initial establishment. If an overhead sprinkling system is available, the beds should be wet before planting and kept continuously moist. Equally good results may be obtained by irrigation (fig. 10), in which case the beds are first thoroughly soaked by flooding and then drained just enough to expose the surface on which the seeds are sown, preferably broadcast. Sufficient water is used to keep the alleys full, thus maintaining a saturated bed. This method is especially suitable for a small nursery, but requires a level site. The young seedlings should not be submerged, for development is then checked and more mortality will occur, especially on hot, sunny days.

Germination occurs within 12 to 24 hours after sowing. The seedling develops very slowly at first, but accelerates steadily and rapidly after about 3 weeks of growth.

Shades or screens help to conserve and maintain uniform surface moisture, but are necessary only if sufficient moisture cannot otherwise be maintained. Half-shade provided by a screen made of laths stapled to wire is suitable.

If the beds are overstocked, the seedlings should be thinned when about 4 weeks old to approximately 20 trees per square foot. Subsequent culture is the same as for most other tree species. The beds will need several weedings, especially when the seedlings are small. This involves hand-picking if the seeds were broadcast, but on drill-sown plots may be largely done with a hoe. The trees should be watered generously during the summer.

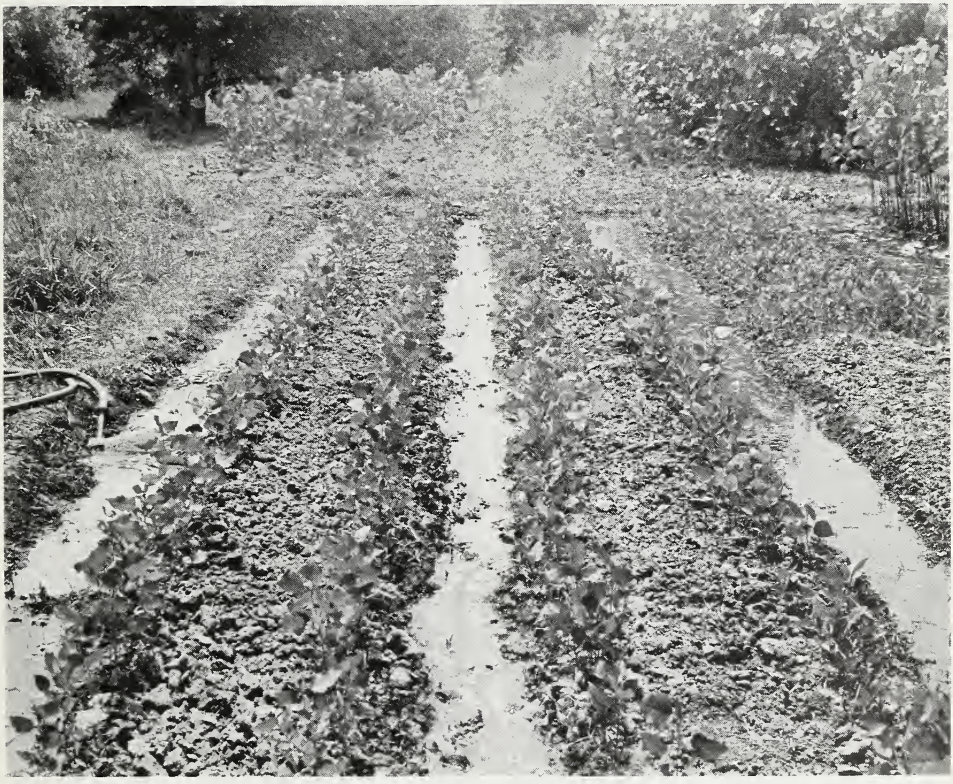


Figure 10.—*One-month-old cottonwood raised from seed in a nursery. Note arrangement of rows on the narrow bed and method of flooding the alleys to keep beds continuously moist.*

PROTECTING THE PLANTATION

Cottonwood plantations must be guarded against fire, grazing, and insects. They should also be closely examined for disease and other kinds of damage.

FIRE

Even a very light burn will kill seedlings and young trees. Larger trees are a little more resistant but those that do survive become badly scarred and soon develop serious butt rot. Even one fire of moderate intensity can kill trees 6 to 10 inches in d.b.h. (fig. 11). All this emphasizes the need for fire protection in natural stands of cottonwood as well as in plantations. Where natural firebreaks like roads, trails, and sloughs do not break up the area into blocks of approximately 40 acres, 15-foot firelines should be plowed. Firelines should also be made around the boundaries of the stand or plantation.

Figure 11.—*One year after a summer fire ran through a 12-year-old cottonwood plantation. Left.—As the leafless branches indicate, nearly every tree is dead. Average tree d.b.h. was 6.5 inches and average height was 53 feet. The stand will be a total loss, since it is below merchantable size. Right.—Bark at the base of this fire-killed tree is loose, and wood-rotting fungi are fruiting all along the bole. Rapid decay makes prompt salvage necessary if fire-killed trees are of merchantable size.*

GRAZING

Cattle and other livestock seriously damage small cottonwoods by trampling and browsing at all seasons of the year. Where deer are numerous, they are likely to strip young trees of their bark in winter and of their early leaves in spring, when other deer food is scarce. Both livestock and deer kill many trees and cause others to be weakened or to have multiple sprouts. Livestock should be fenced out before cottonwood is planted. Deer damage to fruit trees has been controlled by spraying the trees with repellents, but these preparations do not appear to have been tested on cottonwood.

RODENTS

Rabbits may gnaw the bark of small trees in winter, sometimes completely girdling them. Usually the trees sprout again, but often with reduced vigor; at best one or more seasons' growth is lost. Repellents have been partially effective, but except where heavy damage is expected it is doubtful if their expense is warranted. An effective rodent repellent can be made by stirring 5 pounds of liquid asphalt paint into 3-1/3 quarts of water and adding 3-1/3 pounds of copper carbonate, plus enough water to make up 4 gallons. This mixture is sprayed on the cuttings after they are planted.

INSECTS

About a dozen different insects have been observed to attack cottonwood in nurseries, plantations, and natural stands, but only a few have so far proven serious. Boring in the stems and twigs and defoliation are the two chief types of damage.

Most harmful is the cottonwood twig borer *(Gypsonoma haimbachiana)* that attacks the growing branch tips and prevents the twigs from elongating normally (fig. 12). Terminal tips are often killed,

Figure 12.—*Left: Twig borers killed the young branch tips on this 1-year-old cottonwood and produced a stunted, bushy plant. Right: This tall, straight tree is also 1 year old, but was not attacked by borers.*

and the tree becomes bushy and stunted. The caterpillar that does the damage is whitish with a brown head, and about ¼-inch long when full grown. The adult is a grey moth.

The damage is most easily recognized by the short distance between leaf scars, the orange-brown interior of damaged twigs, and exit holes near the leaf scars. The insect is important in both nurseries and plantations. Definite controls have not yet been proven, but in two years of tests dipping half the length of the cutting at planting in a systemic poison, 44 percent Thimet-carbon dust, has been successful. As soon as the material is marketed, its use on all new plantations should be beneficial. The present treatment is effective for only one year, but some way of protecting the trees in following years is being sought.

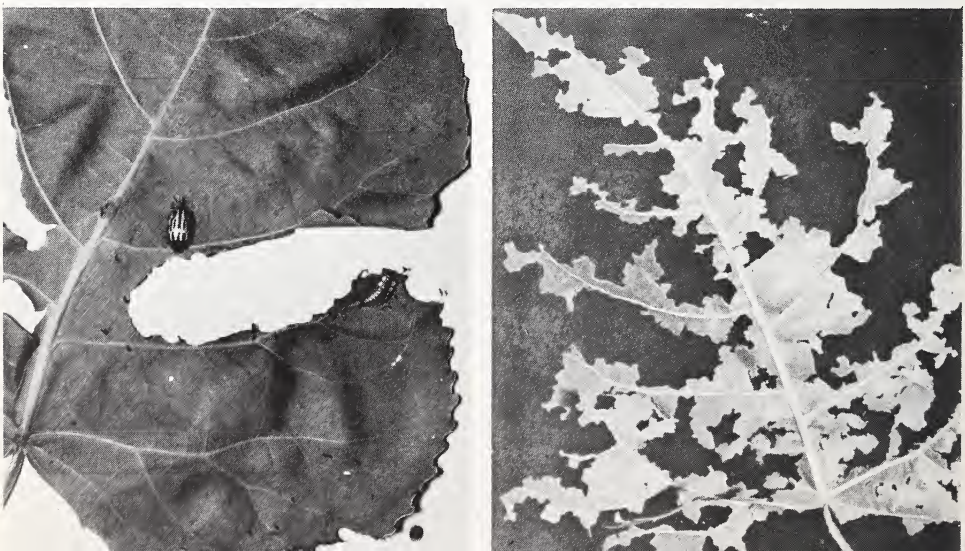
The cottonwood root and stem borer *(Paranthrene dollii)* is a clear-wing moth. The adult has a brown body and dark wings; wingspread is about 1½ inches. The larvae make tunnels as much as 6 inches long in the pith and wood of young root crowns and lower stems. An important indication of attack is the hole that is kept open to the outside for the escape of the adult moth. The caterpillar is white or pinkish, has a brown head, and is about 1 inch long when fully grown.

In nurseries the tunnels of this borer cause sprouts to break off. A basal spray of 5-percent DDT emulsion applied in April and August should help control the pest. Natural enemies seem to check it in natural reproduction.

The cottonwood leaf beetle *(Chrysomela scripta)* eats the foliage. It attacks trees of all sizes but is most damaging to young seedlings and saplings, which are often completely stripped of their leaves. Nurseries and young plantations are therefore most susceptible. The adult is a ¼-inch black and yellow striped beetle much like a potato beetle. The larvae, black in color, grow to ½-inch in length and when disturbed give off a pungent odor that is easily recognized. Both adults and larvae feed on the leaves, which they characteristically strip to the veins and mid-ribs. They are normally controlled by the lady beetles, which feed on the eggs and pupae. Heavy infestations can be checked by aerial or ground spraying with an emulsion containing either 0.05 pound of dieldrin or 0.2 pound of endrin per gallon. These formulations should be applied at the rate of 1 gallon per acre.

These three insects are the most important in cottonwood propagation. Their attacks appear to be aggravated in locations where the drift from cotton insect poisoning chemicals kills the natural predators.

Figure 13.—*Both adults and larvae of the cottonwood leaf beetle feed on the leaves and succulent young tissue of cottonwood and willow trees.*



Among insects of minor importance is the blotch leaf miner *(Paraleucoptera abella)* that works on the leaves in late summer and early fall. The small white "tents" that the larvae spin are very noticeable. The damage comes after most of the growth for the year is complete. The cottonwood borer *(Plectrodera scalator)* is a large long-horn beetle with showy black and white markings; the yellowish caterpillar has brown jaws. The larva tunnels in the basal portions of young saplings, but the worst damage is to older trees, where the tunnels are a serious defect in the lumber. Two other borers, the carpenter worm *(Prionoxystus robiniae)* and the aspen borer *(Saperda calcarata),* both having caterpillars 1 to 2 or more inches long, cause damage much like that of the cottonwood borer. Larvae of the sawfly *Pteronidea populi,* small greenish caterpillars with dark spots along the back and sides, sometimes defoliate trees early in fall. Stem galls on the leaves, caused by the aphid *Pemphigus populi-transversus,* are frequently very numerous, and the common grasshopper *(Melanoplus* spp.) feeds on the bark of 1- to 3-year-old trees in late summer and early autumn.

Insects seem to concentrate their attack on the poorer sites and the weaker trees, so that any cultivation or other practice which produces healthy, vigorous trees reduces likelihood of damage. In plantations under exceptionally heavy attack, it is probably wise to cut and burn the infested trees. Infested stumps in the nursery, and all refuse from the production of cuttings, should likewise be destroyed. All cuttings gathered for planting should be examined to exclude and destroy those containing borers.

DISEASE

No important disease has as yet been observed on cottonwood plantings. The poplar canker *(Cytospora* sp.) frequently kills some of the less vigorous and weakened young trees. It is most noticeable on the poorer sites where growth is slow. The trees usually die in late fall or winter; the inner bark on the main stem is attacked and killed first. This canker is very common, and the causal fungus lives either on dead wood or live wood of low vitality. The only remedy seems to be to avoid the poorest sites and to cultivate or release trees before growth is seriously retarded.

A rust fungus of the genus *Melampsora* sometimes defoliates cottonwoods of all ages. The rust forms yellow spores on the lower side of the leaves, and dead leather-colored patches on the top. Slight evidences of this disease are noticeable almost every year, and sometimes trees are almost defoliated. In the Mississippi Delta intermittent loss of leaves does not kill the trees, but slows their growth. In climates with more severe winters it is reported to kill many trees. Trees defoliated in midsummer sometimes put on new leaves the same season. There is no satisfactory control, but damage is seldom severe enough to endanger a plantation.

COSTS AND RETURNS

While more information on costs and yields would be desirable, current knowledge strongly suggests that, where sites are good, cottonwood plantations are among the best opportunities in forestry.

The major influences on planting costs are source of stock, tree spacing, condition of the site and amount of preparation required, and frequency and intensity of cultivation. Table 2 estimates probable costs, in 1960 dollars, of establishing stands under proven practices. Two types of site are considered—abandoned cropland and areas of rundown woods and worthless brush. Chiefly because of the difficulty of site preparation, wooded areas are likely to require at least double the investment necessary on old fields. As will be seen, their extra cost does not rule out woods plantations as good investments, though it suggests that, where there is choice, the easier sites should be planted first.

Table 2.—*Costs per acre of establishing a cottonwood plantation at 10- by 10-foot spacing (436 trees per acre)*

Operation	On abandoned agricultural land	On wooded land[1]
	Dollars	*Dollars*
Site preparation		
Bulldozing	...	18.80
Debris reduction	...	1.75
Crossdisking entire area	2.50	2.50
Total	2.50	23.05
Planting stock		
Raising cuttings in nursery	.40	.40
Harvesting and preparing cuttings	1.35	1.35
Total	1.75	1.75
Planting		
Subsoiling and row marking	1.50	...
Setting trees	2.00	3.50
Total	3.50	3.50
First-year cultivation		
2 crossdiskings with wheel tractor	4.75	...
4 crossdiskings with wheel tractor	...	9.50
1 supplemental hoeing	6.00	6.00
Total	10.75	15.50
Grand total	18.50	43.80

[1] Costs on woods sites are from: Moore, H. 1958. Planting cottonwood cuttings, Proc. Seventh Annual Forestry Symposium, La. State Univ., pp. 10-15.

Yields of mature cottonwood plantations have not yet been determined in the Yazoo-Mississippi Delta. The estimates in Table 3 are from unthinned, fully stocked natural stands as documented by Williamson.[5] The volumes shown as removed prior to the final harvest represent a cutting of only those trees that would otherwise die of overcrowding as the stand grows. The pulpwood volume includes both the amount in pulpwood-size trees and topwood from larger trees.

The table assumes that the trees will average 17 inches d.b.h. at age 30; volume per acre, including that removed before then, should be about 19 thousand board feet plus 45 cords of pulpwood. The stand might be harvested at age 30, but as the trees would still be growing rapidly the table also considers the possibility of holding them to age 42. By then they would average 23 inches in d.b.h., and would have produced 33.5 thousand board feet per acre, of which about 60 percent would be in veneer logs, plus 59 cords of pulpwood. Possibly these estimates are less than the growth attainable in well-managed plantations on good sites.

The dollar values in the table were calculated on the assumption that stumpage will be worth $2 per cord for pulpwood, $20 per MBF for saw logs, and $30 per MBF for veneer logs.

[5] Williamson, A. W. **Cottonwood in the Mississippi Valley.** U. S. Dept. Agr. Bul. 24, 62 pp., illus. 1913.

Table 3.— *Estimated volumes and values per acre, of 10- by 10-foot cottonwood plantings*

Cutting age (years)	Volume removed				Volume left	
	Pulpwood	Sawtimber	Veneer logs	Stumpage value	Sawtimber trees	Topwood and pulpwood trees[1]
	Cords	*MBF*	*MBF*	*Dollars*	*MBF*	*Cords*
30-year rotation						
12	7.4	0.0	0.0	14.80	0.2	0.2[2]
18	8.4	.0	.0	16.80	4.1	12.0
25	4.8	.0	.0	9.60	10.7	14.6
30	24.4	11.5	7.7	509.80	.0	.0
35	...	...	...	...	...	...
42	...	...	...	...	...	...
42-year rotation						
12	7.4	.0	.0	14.80	.2	.2
18	8.4	.0	.0	16.80	4.1	12.0
25	4.8	.0	.0	9.60	10.7	14.6
30	4.6	.6	.0	21.20	19.2	20.5
35	4.7	1.4	2.0	97.40	27.5	27.5
42	29.5	11.8	17.7	826.00	.0	.0

[1] Includes only pulpwood-size trees (7-14 inches d.b.h.) and topwood in larger trees. A cord was assumed to equal 90 cubic feet. Topwood was computed as 1 cord per thousand board feet of logs cut.

[2] Plus 319 trees below pulpwood size.

Table 4 estimates rates of return on money invested in cottonwood plantations growing at the rate suggested by Table 3. The estimates are for 3 kinds of site and 2 methods of computation. If their land is already paid for or if the area to be planted is a small part of other holdings, property owners will probably choose the computational method that excludes land cost and taxes. Commercial operators who are acquiring land for planting should use the first method; here, land cost was estimated at $15 per acre, taxes at 50 cents per acre annually on lands protected from flooding and 5 cents on unprotected, and 5 cents per acre for controlling or preventing grazing and fire.

As standard procedures were followed in computing the compound rates of return, the table can be used to compare cottonwood planting with other investment opportunities. Comparisons should be on an after-tax basis because timber revenue can be reported as capital gain.

Whichever way land costs are computed, the returns in Table 4 compare well with those obtainable from other kinds of investment. The 42-year rotation, though showing a slightly lower rate of return than the 30-year, yields more than twice as much veneer log volume, a factor most desirable for many growers.

Finally, the forecasted rates of return are likely to prove conservative for reasons other than those connected with the

Table 4.—*Estimated rates of return on money invested in cottonwood planting*

	On submarginal agricultural land		On run-down wooded land			
			Protected by levee		Unprotected	
	Age 30	Age 42	Age 30	Age 42	Age 30	Age 42
	Percent					
Including land cost and taxes	9.9	8.9	7.8	7.3	8.1	7.6
Excluding land cost and taxes	13.0	11.4	9.4	8.5	9.4	8.5

estimates of volume growth. Research and industrial experience promise to diminish costs of establishing plantations. Use of cottonwood timber is increasing, yet less than 3 percent of the timber in the Mississippi River Delta is of this species. The acreage that could be put to growing cottonwood is limited. Hence, stumpage prices are likely to rise even if future supplies increase greatly. The commercial advantage that this species holds over others should ensure adequate markets for all that is likely to be produced.